91602
new 82-10

COMPLIMENTARY COPY
Please Credit Ontario Hydro Research if
Reproduced in Whole or in Part

ontario hydro
research division

TO: MR. J.E. MITCHELL
Manager, Technical Services and Development Dept.
Program Support and Services Division
C25F6

THERMAL PERFORMANCE AND DELIVERY CAPABILITY OF A 175 L HYBRID POLYMER STEEL CONSTRUCTION ELECTRIC WATER HEATER

J.A. Riddersma

Test results are presented for a uniquely designed electric water heater which has an independent inner tank cast from a non-metallic composite material. The tank requires no anode rod. When tested in accordance with selected clauses of the CSA Performance Standard for Electric Water Heaters, the tank fell slightly short of most of the requirements.

INTRODUCTION

Standard electric water heaters have a storage tank made of steel with the inner surface covered by a glass lining. This glass lining is often imperfect, and could be pitted with tiny holes and cracks which may expose bare metal, and in turn prematurely cause the tank to rust.

A United States manufacturer has developed a process by which a non-metallic composite is placed inside the solid steel containment capsule and cast to form a seamless "tank within a tank". The manufacturer claims that because the inner tank contains no flaws, and no bare metal is exposed, the need for an anode rod is also eliminated.

The tank has a top inlet (dip tube) for the cold water.

A 175 L (nominal) model of one of the above tanks was tested. The results are presented in this report.

job	file	date	report no.
12-144	814	January 24, 1991	91-15-K

91-07178/

LEGAL NOTICE

This report was prepared by Ontario Hydro and, while effort has been made to assure the accuracy and applicability of the material contained herein, neither Ontario Hydro nor any person acting on its behalf:

(a) makes any warranty, express or implied with respect to the use of any information, apparatus, method or process disclosed in this report or that such use may not infringe privately owned rights; or

(b) assumes any liabilities with respect to the use of, or for damages resulting from the use of, any information, apparatus, method or process disclosed in this report.

TEST METHODS AND INSTRUMENTATION

The following tests described in the January 1990 draft of CSA Standard C191, "Performance of Electric Storage Tank Water Heaters", were performed to establish the thermal performance and delivery capabilities of this water heater: Tank Capacity (Clause 5.4), Energy Efficiency (Clause 5.6), Delivery (Clause 5.11), Diffusion (Clause 5.7), Upper Zone (Clause 5.10), Heating Element Input (Clause 5.5), and Thermostat Tests (Clauses 5.8.1 and 5.8.2).

All tests were performed at the OHRD Water Heating Test Facility.

Tank temperatures, water flow rates, and electrical energy consumption were recorded, verified, and stored in machine readable form for analysis.

TEST RESULTS AND DISCUSSION

Table 1 summarizes the results of the tests performed. Test results in more detail are found under the respective subheadings.

Tank Capacity Test

The tank capacity was measured using a nutating disk flow meter. Total volume at line pressure was 179 L. The CSA standard stipulates that the tank volume must be within +7%, -0% of its stated capacity. For this reason, to meet CSA Standard C191, this tank can officially be labelled a 166 to 179 L model. A standard capacity is 175 L.

Energy Efficiency (Standby Loss) Test

The energy efficiency test results are graphically illustrated in Figure 1. The standby loss for this tank was 100 W. The new CSA standard allows for a loss of up to 97 W; consequently, this tank failed to meet the requirements of this test by 3 W. Investigation showed that there was a small piece of insulation missing from the top of the tank, between the inlet and outlet connections. Insulation of this area should reduce the standby heat loss.

Delivery Test

The hot water delivery requirements were not met by this tank. The tank was unable to maintain the standard delivery temperature when subject to 16 daily withdrawals totalling 454 L (Table 2). The lower thermostat of the tank was set for a 56°C rise above the inlet temperature of 16°C, as required in the standard. The upper thermostat was not adjustable, and therefore could not be set to the required temperature. A water heater is deemed to have failed a delivery schedule if the difference between the average outlet temperature and the inlet temperature drops below 44°C, except that one draw may drop to 39°C above the inlet temperature. Figure 2 is a

differential graph which shows the average outlet temperature minus the inlet temperature (*outlet temperature rise*) during the draws.

It appears from the data that the top element did not operate during the delivery test. This is attributed to the low setpoint of the upper thermostat (47.5°C) in relation to the water temperature requirement for the test (72°C). Use of an upper thermostat with a higher setpoint may improve the performance of the tank during the delivery test.

Diffusion Test

The diffusion test indicated that the percentage of the total tank volume of hot water delivered before the outlet temperature dropped 17°C below the setpoint was 89.4% (159 litres). The minimum requirement for this test is 90% (161 L). Consequently, the tank failed this test, but only by a small amount (2 L). Figure 3 shows the results of this test graphically.

Upper Zone Test

The upper zone test determines the volume of water heated by the top element. The test is conducted on a cold tank with the lower element disabled. The upper element is operated until cycling off thermostatically. The thermostat is supposed to be set for a 56°C rise above the inlet temperature. For the tank tested, the thermostat was not adjustable, and had a setpoint of about 47.5°C. Water was drawn off at 18 L/min, until the outlet water temperature dropped 17°C below setpoint. Figure 4 shows that 42 L (23.5% of the total tank capacity) of hot water were provided by the tank before the discharge temperature declined 17°C. The CSA requirement is 25 $\pm$ 2.5% of the tank volume; in this case 45 $\pm$ 4.5 L. This tank passed the CSA requirement.

Heater Element Input Test

Heater element input was measured for both elements. The measured power inputs to the upper and lower elements were 3470 and 3650 W respectively. The upper element failed to meet the CSA requirement of 3800 W $\pm$ 5% (190 W); the lower element met the standard requirement.

Thermostat Tests

Section 3.4.1 of the standard stipulates that thermostats shall be provided with a range of adjustments so that the lowest cut-out temperature shall be not greater than 50°C and the highest cut-out temperature for household use shall be 77°C.

Section 3.4.3 of the standard stipulates that the controlled temperature differential for the lower thermostat shall be not less than 3°C, and not more than 8°C; the upper thermostat must have a controlled temperature differential of not less than 8°C and not more than 17°C.

The lower thermostat's lowest cut-out temperature was 48.3°C; its highest was 72.1°C. This is acceptable under the standard. The controlled temperature differential, however was only 2.4°C, which is below the standard requirement of 3°C.

The upper thermostat of this tank was factory set and unadjustable. Its cut-out temperature was 47.5°C, which is acceptable under the standard. The controlled temperature differential was 10.1°C which is also acceptable under the standard.

Thermostat calibration test results are not available because the thermostats did not have specific temperature markings.

Table 1
175 Litre Tank Test Results

Test Name and Clause	Test Requirement	Test Result	Pass/Fail
Tank Capacity (Clause 5.4)	N/A	179 L	N/A
Energy Efficiency (Clause 5.6)	< 97 W	100 W	Failed
Delivery (Clause 5.11)	See "Delivery Test" Subsection		Failed
Diffusion (Clause 5.7)	90% (161.5 L)	89.4% (159 L)	Marginal
Upper Zone (Clause 5.10)	25 ± 2.5% (45 ± 5.5 L)	23.5% (42 L)	Passed
Heating Element Input (Clause 5.5)	Upper/Lower 3800 ± 5% (190W)	3470 W/ 3650 W	Failed/ Passed
Thermostat Adjustment (Clause 5.8.1)	Upper/Lower 50°C<77°C	47.5°C/ 48.3°C	Passed/ Passed
Controlled Temperature Differential (Clause 5.8.2)	Upper 8°C<17°C Lower 3°C<8°C	10.1°C 2.4°C	Passed Failed

CONCLUSIONS

When tested in accordance with selected clauses of the CSA Standard C191/1990:

1. The standby loss of this tank was slightly higher (by 3 W) than the 1990 version of the standard requirement (100 W versus 97 W).

2. The tank failed to meet the delivery requirements as set out in the standard.

3. The performance of the tank in the diffusion test was marginal (2L below the requirement).

4. The tank passed the upper zone test.

5. The upper element failed the power input test; the lower element passed.

6. The lower thermostat failed the temperature differential test by 0.6°C; the upper thermostat passed.

Note: Minor changes in the design could make this tank comply to the requirements of CSA Standard C191/1990 that are referenced in this report.

Approved by:

A.F. Baljet
Manager
Electrical Research Department

Submitted by:

J.A. Riddersma
Technologist
Utilization Section

Reviewed by:

C. McGugan
Engineer
Utilization Section

JAR:

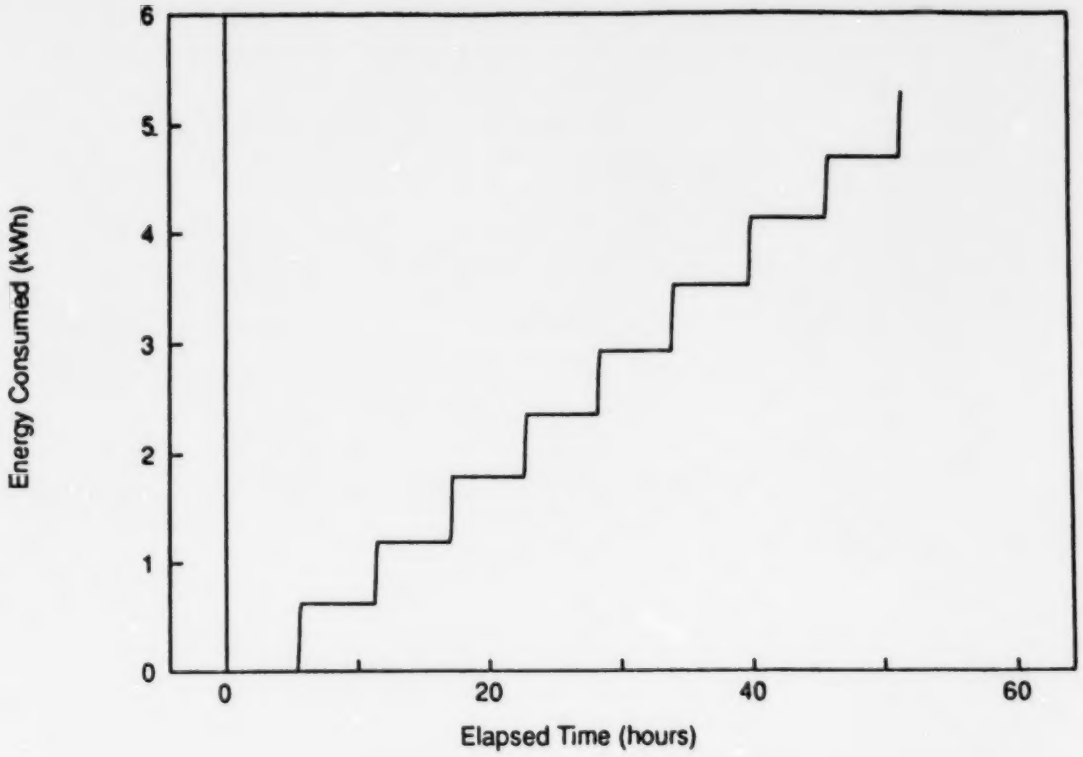

Figure 1 - Energy Efficiency Test

Table 2 - 454 Litre Delivery Schedule

Withdrawal Number	Elapsed Time (hours)	Withdrawal (litres)
1	0	40
2	1	41
3	2	46
4	3	90
5	3.5	81
6	4	50
7	5	14
8	6	14
9	7	14
10	8	5
11	9	14
12	10	9
13	11	9
14	12	14
15	13	9
16	14	4

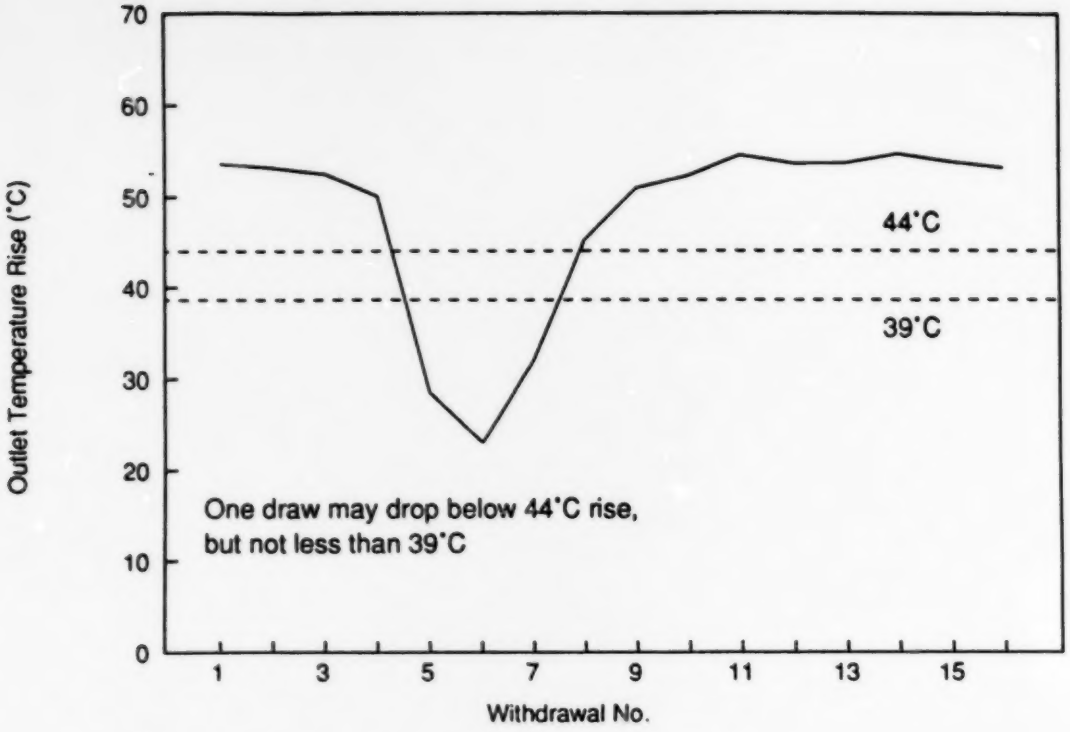

Figure 2 - Delivery Test

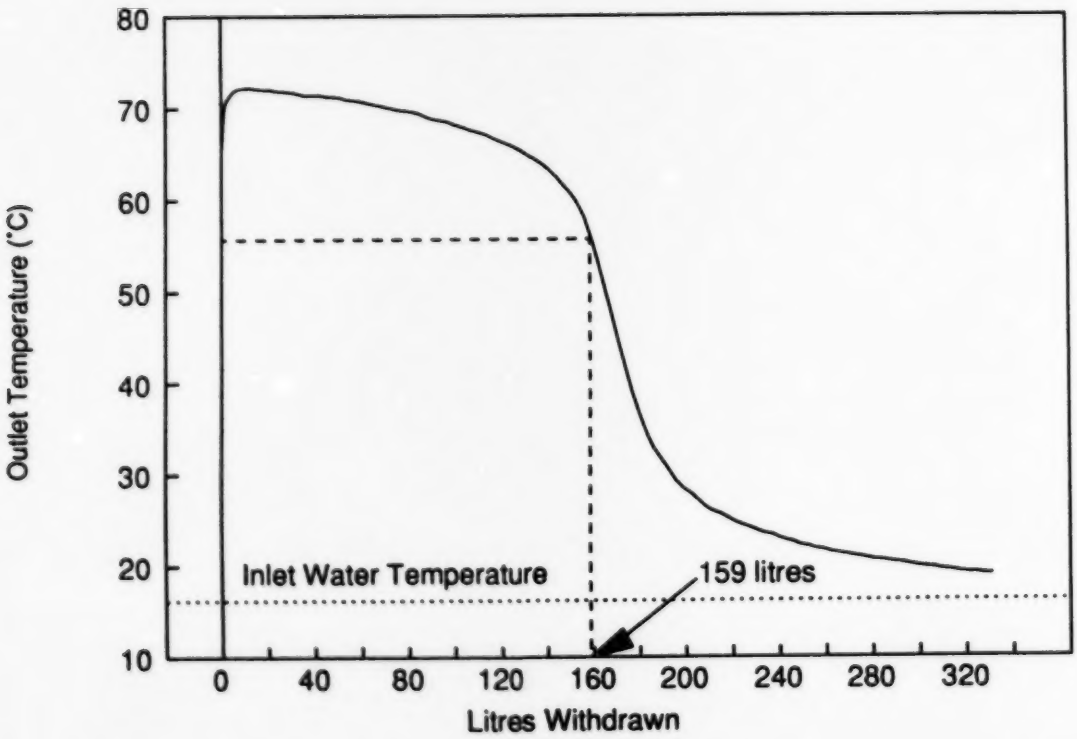

Figure 3 - Diffusion Test

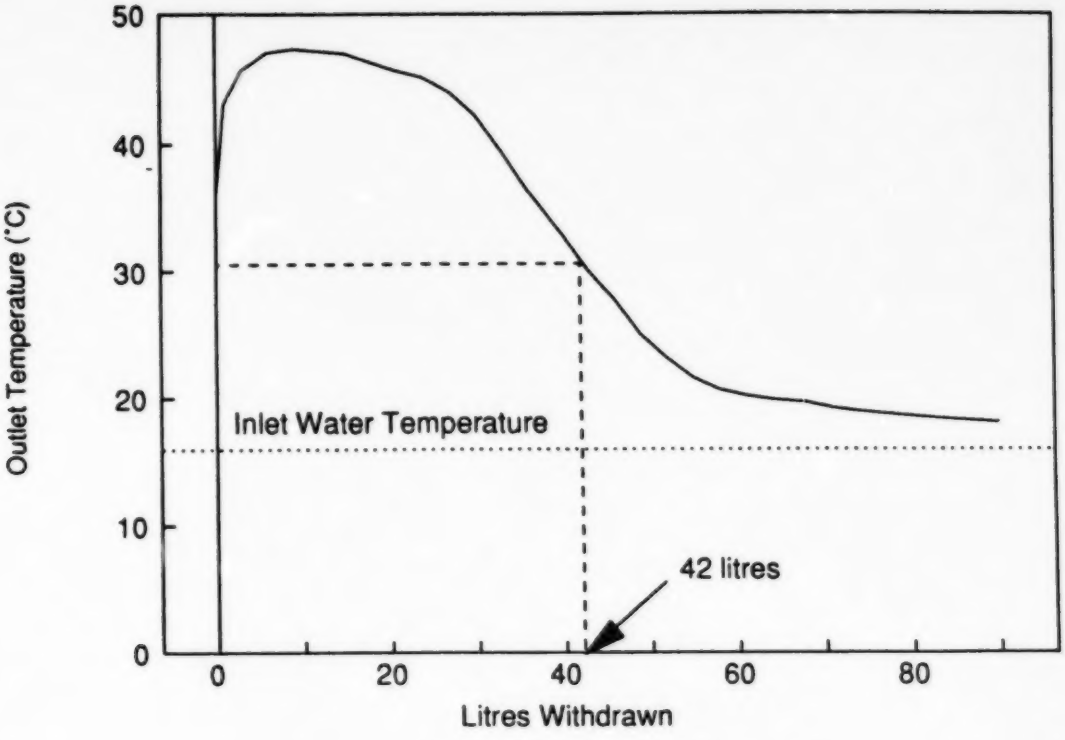

Figure 4 - Upper Zone Test